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RECENT ADVANCES IN 3D PRINTING FOR CURRENT CHALLENGES, MATERIALS AND THEIR USES

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ABSTRACT

Cumulative Manufacturing (AM) technology in 3- D printing has grown into a great field in moment's technological world, especially in manufacturing sectors. Colorful AM technologies have been developed presently and their advancement has been reused worldwide is presented. Their advancement included usability and comity of the different types of material. also, the operations of 3- D printing via different AM technologies in biomedical operations, dental implants, pharmaceutical diligence, chemical processing outfit, structural factors, automotive diligence, marine sectors, aerospace sectors, sports outfit and food processing diligence have been presented. Still, suggested operations via different AM technologies have also been reported. Further, the challenges in development of the 3D structure via different AM technologies have also been bandied. The remedial/ treatment like pre and post processing operations, tool path planning, and slicing exposure have also been suggested in printing of the sound 3D complex structure.

Keywords: Cumulative Manufacturing, 3- D Printing, Accoutrements, Operations, Challenges.

I. INTRODUCTION

There have been colorful traditional and non-conventional styles to fabricate the 3D structure in order to meet the consumer prospects. The revolution in assiduity has drastically changed from conventional to advanced manufacturing processes like rapid-fire prototyping, cumulative manufacturing. Advanced manufacturing means structured and effective product, which involves computer modeling, simulation, and design. Cumulative manufacturing is the advanced manufacturing process that is a foundation in the third artificial revolution which has been for over the once three decades. Lately, Additive Manufacturing (IS) also known as

Three- dimensional (3- D) printing or rapid-fire prototyping, got attention due to an effective product methodology approach. Also, this technology has got further attention due to expiry of the major patents. The last patent in AM has been expired in 2009 on fused deposit modeling (FDM), latterly the technology was also accessible by numerous distinct diligence and 3- D printers could be manufactured without violating intellectual property rights.

The terms AM and 3- D printing have been indistinguishable. The word AM refers to the technology of accumulating progressive subcase of material over one another, producing final 3D structure through CAD model data. Still, 3- D printing is the technology that prints 3D structure through deposit of layers of accoutrements with the help of print hothead, extruder snoot or any other printing process. In the AM technology, the rapid-fire prototyping was the first operation where the 3D model have been produced effectively which has to suffer farther quality control and examination tests before mass product. Preliminarily, Charles (Chuck) W. Hull in 1980 successfully published the 5 cm altitudinous tea mug with stereo lithography outfit (SLA- 1), an AM technology. Towards the end of the 1980s, picky ray sintering (SLS) technology has been the new revolution in greasepaint metallurgy processing which was developed at University of Texas by C.R. Deckard. In this SLS technology, pulverized patches were melted by focused ray shafts. Further, C.S. Crump constructed fused deposit modeling (FDM) technology in the late 1980s. In his invention, the accumulation of thermoplastic material took place subcase- by- subcase through a3- axis robot. The outfit and procedure which have been used in this FDM technology was patented in 1992 and innovated Stratasys Inc. After the development of these technologies, there were no practical operations in diligence that were enforced due to being precious as compared to being technology. It has been employed in diligence for prototyping and exploration purposes until 2000. With the morning of the twenty-first century, technology gradationally came popular and endured a phenomenal rise in its marketable operations not only for prototyping purposes but also in final part product in colorful distinct fields. Moment 3- D printing has surfaced as an artificial revolution and nearly every assiduity is being affected by AM whether it's the food assiduity or the construction10. Over the once decade, AM ways have fleetly converted our approach to design, develop, introduce, and produce new products. 3- D printing has come a major tool for every assiduity and plays a major part in driving competitiveness either by acting as a source of product invention or as a motorist of force chain metamorphosis.

II. METHODOLOGY

Colorful cumulative manufacturing processes were developed commercially with their own advantages and limitations. Veritably first author JP Kruth in 1991 proposed an intriguing bracket grounded on the metamorphosis of the material, types of outfit used and the process itself. Further, and his platoon suggested an academic bracket in 2011, but it was of no major impact in terms of practical work. Besides, ASTM Standard F2792 – 12a, distributed the AM technology into seven orders (Fig. 1) i.e. handbasket photo polymerization, distance lamination list, greasepaint bed emulsion, material jetting, material extrusion, directed energy deposit and binding jetting18. In the meantime, ISO also proposed the draft in 2010 for the bracket of AM technology into ten orders videlicet digital light processing, fused subcase modeling/ manufacturing, ray melting, ray sintering, subcase laminated manufacturing, mask sintering,multi-jet modeling, poly- spurt modeling, 3D printing, and stereo- lithography. Further, ISO assumed the ASTM bracket with its standard ISO/ ASTM 529002015 in 201519.

Colorful experimenters reported their work as per used material in development of the 3D complex structure through different AM technologies20. But the verity of the material's operations is limited with AM technology. Still the different types of accoutrements operations are in development stage. Some of the accoutrements like essence and blends, pottery, polymers, mixes and other suitable material were delved and presented in Fig. 2. Either, the different material operations with different AM technology used in publishing the 3D complex structure is bandied in posterior section.

3D printing of essence has gained important attention in aerospace, machine, health, and manufacturing assiduity due to its wide range of operations. Generally, in this 3D printing process, essence in greasepaint or line form was used as per the needed operation to meet the asked parcels. Colorful power sources similar as a ray or an electron ray was employed to melt the essence greasepaint to produce a solid part in subcase by subcase manner. In essence grounded printing, PBF and DED were the most common ways in publishing 3D corridor. Besides this, other styles developed lately similar as binder jetting, cold spraying, disunion stir welding, direct essence jotting and diode- grounded processes. These processes have great advantages over the being one printing technology (PBF and DED). Presently, colorful essence maquillages and their blends similar as SS, Al, Ti, Ni, Co, and Mg have been used.

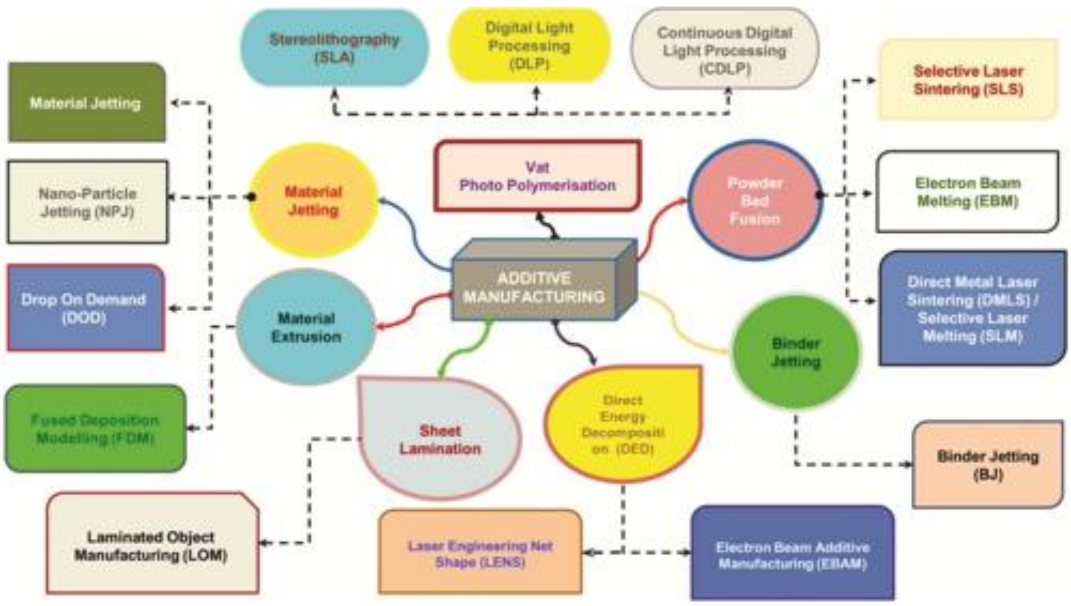

Fig. 1. Additive Manufacturing Process Classification

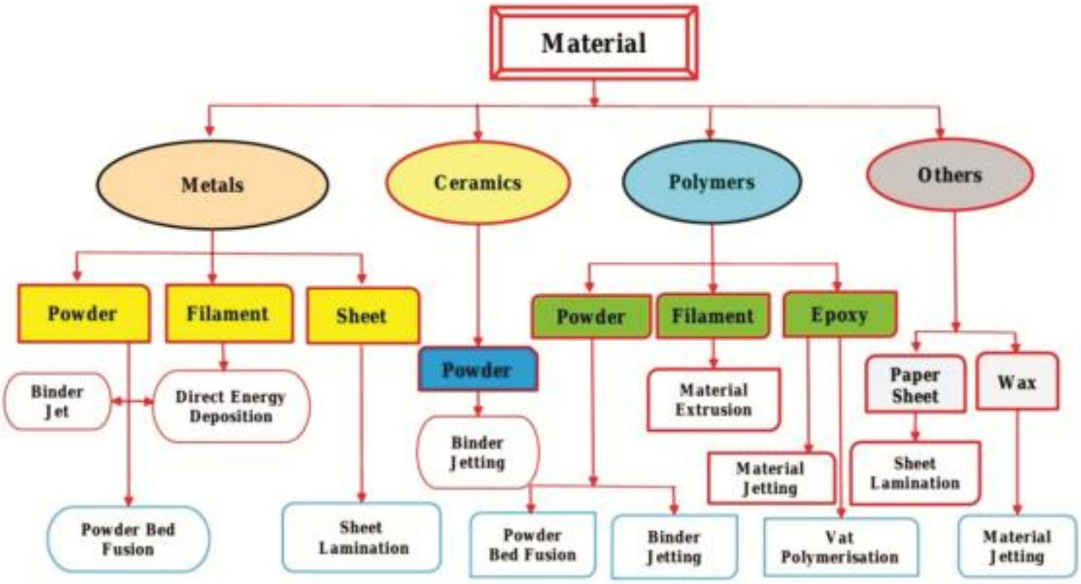

Fig. 2. Different types of materials used in AM Process

The polymers used in the publishing the part was hair/ greasepaint type and resin type. In hair type, the plastic should melt to form the design of the part and in resin type; the polymer is solidify to form a part. Each polymer needed different process parameters during printing process and produces part varying parcels. The polymers available in 3D printing process is ABS(Acrylonitrile Butadiene Styrene), ABA, PTE(Polyethylene terephthalate), PETG or glycolized polyester, PC Polycarbonate), PLA(polylactic acid), and high performance polymers like PAEK(polyaryletherketones) or PEI(polyetherimides), PP(Polypropylene), Nylon. The ABS maquillages were generally used in polyjet, SLA and SLS technology to form the part design.

III. MODELING AND ANALYSIS

The part designing through 3- D printing has colorful challenges like shape optimization, allocation of supports, error in figure in slice model i.e. STL train, exposure in designing the part, tool path planning, commerce of two ray ray intensity at a particular point, pre and post processing operation to achieve delicacy in part designing is presented in Fig. 3. Either, limitations of the machine like speed of the process, lack of multi material processing, and tackle comity is developed in Table 1. The below said challenges and limitations in carrying the finished and accurate part through 3- D printing is bandied below in detail. Shape optimization term used to fill the design space effectively by optimizing the design parameters like mass, volume, and strength. Two styles videlicet geometric shapes and topological optimization generally used to allocate the material effectively to fill the design space. The shape optimization of part has significant impact on electric energy, product time, and material saving which made low cost of product. In shape optimization the design distance was divided into separate lower cells containing mesostructured. It was the grueling task to find the confines and placement of the mesostructured in cellular structure when layout of cells was defined. To satisfy the constraints of cellular structure the algorithm was demanded to define the needed model. The algorithms only fill the design space with cellular structure without considering mechanical parcels. The design space filed in the cellular structure could be thousands to ten thousands depending on the size of the part. In the current CAD system the geometric modeling operations on thousands rudiments were delicate and they were veritably limited of specific constant sizes of cells. Piecemeal from the geometric shapes system to fill design space, the topological optimization was also the volition to fill design space by allocating the material in the design space. The allocation of the material in design space was grounded on material parcels, geometric features, and cargo conditions. The ideal of topological optimization was to minimize maximize the objective function with their constraints.

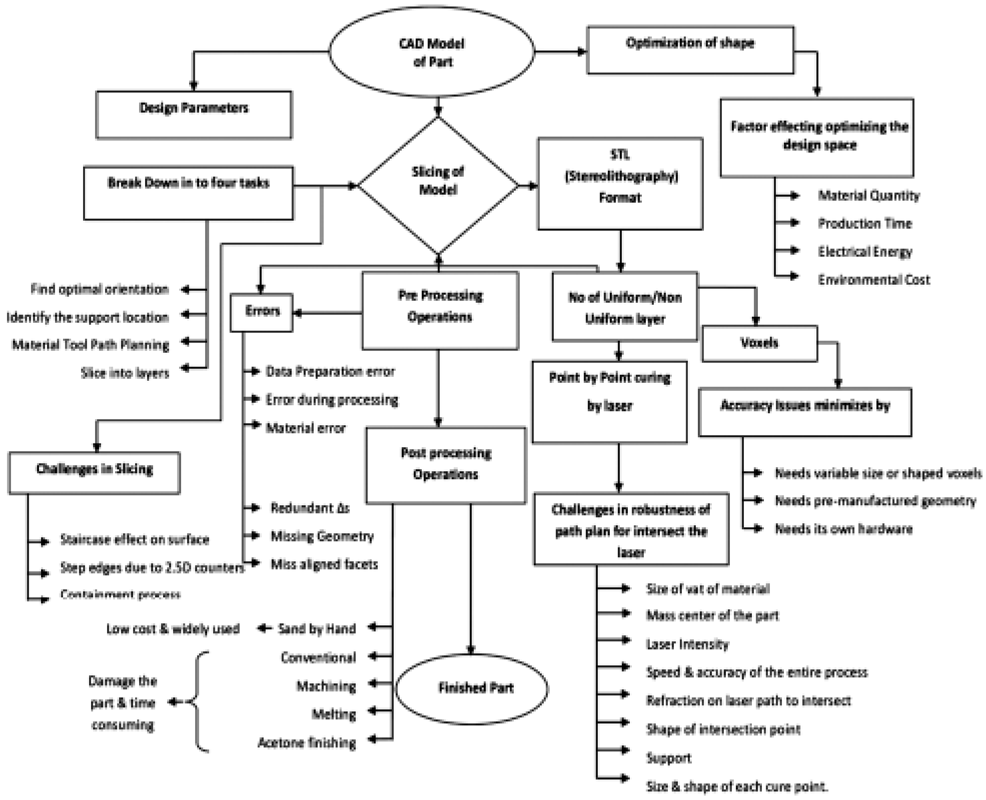

Fig. 3. Challenges in designing the part via 3D printing

Table. 1. Limitations and challenges in rapid prototyping

Classification	Limitations and challenges AM technology
Equipment cost	Relatively high as compared to conventional machines in mass production.
Material cost	Special care is needed in storage of material like polymers that makes cost at higher side. Pre processing of material like to form into required size powder/filament is needed. In some cases, coating is required.
Processing time	The processing/fabrication time is relatively slow. Shorter time is needed in fabrication for small size components.
Types of materials	Different variety materials like Polymers, metals, ceramic, and hybrid materials are limited. Building of prototypes limited to one material. Multi material printing is in researchable stage
Size of the prototype	Larger the size of prototype need larger time of production (few hours to days)
Accuracy of the fabricated component	Shrinkage and distortion is the common defect in production of prototype parts
Surface Finishing of fabricated component	Limited resolution produces poor finishing. The surface finishing is generally less as compared to injection molding and CNC machining.
Post Processing	The post processing is needed to remove the supports, finish the part, cleaning of nozzle. Post processing operation varies depending on the fabricated component.
Performance	Properties of the printed part may vary depending on the AM technology adopted in printing the part.
Prototyping Assembly	The physical representation of assembly of the fabricated parts through AM is not reported yet.

IV. RESULTS AND DISCUSSION

With the morning of the AM technology, it was gaining attention in every assiduity and excluded traditional manufacturing processes sluggishly due to its inflexibility and feasibility in developing the complex structural shape. The posterior section is agitating the colorful advantages over the tradition manufacturing process in developing the complex 3D structure. Rapid tooling can be defined as any mound- making system that can fleetly produce tools with the least direct labor. AM rapid-fire tooling can be distributed under circular and direct rapid-fire tooling. Circular rapid-fire tooling AM was used to produce an impermanent part model and also a rear ceramic or beach earth is produced from this model for casting essence corridor. Still, direct rapid-fire tooling created molds and inserts directly with AM processes. Therefore, direct rapid-fire tooling does not involve as numerous way as in case of circular rapid-fire tooling and also has the implicit to conserve the overall element viscosity more effectively. Numerous factors in the traditional assembly process were generally bought from external suppliers, indeed if they were produced in a division of the same plant unit their delivery has to be planned well in advance. generally corridor are manufactured in batches because of lesser effectiveness, which also leads to pumping up of the lead times and supplies further where redundant detention may be there due to queuing problems in case of confined machine capability. Hence, part connection using AM may advance to significant lead- time reductions in the overall force chain. It was dispensable to say that syncopating the lead time from several months to several days will surely affect in the reduction of costs significantly.

V. CONCLUSION

In this study, a thorough review of cumulative manufacturing has been bandied in detail. The technology development to printing of 3D structure with particular technology has been epitomized. From the morning of the AM technology to rearmost advancement in development in printing of 3D complex structure has been presented. Since one decade, AM technology gained attention to introduce the new 3D structure through AM technology that came a major tool for every assiduity. Colorful AM processes have been developed and classified with their own advantages and limitations. Veritably first, AM classified according to type of material use in the printing process. Further, it classified into seven different orders defined by ASTM in 2012. In the meantime, a draft by ISO is also presented to classify the AM process into ten different processes. But in 2015, ISO assumed the ASTM groups with its standard ISO/ ASTM 529002015. The operations, challenges, and limitations of AM processes have been bandied. Still, this technology has colorful challenges like limited accoutrements vacuity, chops deficit, size constraints, slow speed of printing, and slicing of the CAD model exposure in development of the 3D structure. To overcome these limitations the experimenters suggested the colorful styles to short out these issues but they've their own advantages and limitations. Still, the experimenters have been probing the optimum result for achieving the complex 3D structure with enhanced physical and mechanical properties.

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